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Preliminary Design of an Image Quality Tester For Helmet-Mounted Displays

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Helmet-mounted displays (HMDs) provide essential pilotage and fire control imagery information for pilots. However, image quality testers for HMD field performance validation do not currently exist. This research employed techniques from imaging analysis and interpretation, and computer-aided design/computer-aided manufacturing (CAD/CAM) to investigate a preliminary design for a portable HMD image tester.

For this study, a charged couple device (CCD) camera and lens were selected. Hardware characteristics such as viewing angles in horizontal and vertical positions, dynamic working range at day and night, pixel resolution, focal length, and aperture ratio were evaluated with regard to HMD functionality. Experiments to evaluate camera sensitivity and test pattern merits were conducted using a programmable micro positioning system, CCD camera, optical fixtures and benches. Next, the relative ratio among features within the image profile was established and an ideal image profile and evaluation criteria were established based on the experimental results. Third, image processing algorithms and techniques, such as edge detection, were developed and applied in test pattern feature

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detection. A software prototype, including modules for image capture, image analysis, interpretation, and user manuals, was developed. Finally, a concept hardware package design is proposed. This design incorporates a notebook computer with a flat panel display to interface with the camera and software prototype; and incorporates fixtures for the HMD, camera, computer, and power supply. This design will allow the tester to be used in the field.

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Introduction

Helmet-mounted displays (HMDs) are a gateway to the pilot for viewing pilotage and fire control imagery. In Army aviation, the AH-64 Apache helicopter uses an HMD system known as the Integrated Helmet and Display Sighting System (IHADSS). The IHADSS consists of various electronic components and a helmet/display system called the Integrated Helmet Unit (IHU). The IHU (Figure 1) includes a helmet, visor housings with visors, miniature cathode ray tube (CRT), and helmet display unit (HDU). The HDU serves as an optical relay device which conveys the image formed on the CRT through a series of lenses, off a beamsplitter (called a combiner), and into the aviator's right eye (Figure 2). The CRT is 1 inch in diameter and uses a P-43 phosphor. The combiner is a multilayer dichroic filter which is maximized for reflectance at the peak emission of the P-43 phosphor.

The U.S. Army is currently developing the next generation reconnaissance aircraft, the RAH-66 Comanche. This aircraft will incorporate an HMD which will be binocular in design. While its final design is still in review, it will basically consist of two image sources (either miniature CRTs or liquid crystal displays) with two sets of optics, delivering imagery to both eyes.

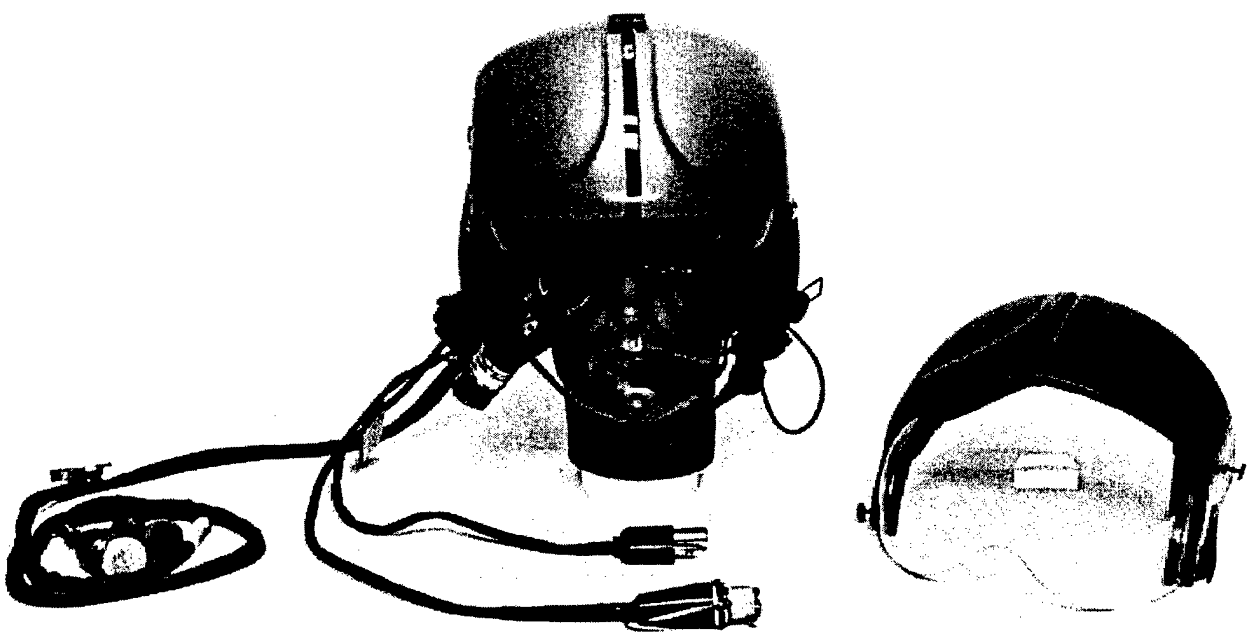

Figure 1. The IHU of the AH-64 IHADSS.

Currently, there is no existing image quality tester for HMD validation in the field. To maintain system integrity and readiness, and to provide pilots with validated pilotage, navigation, and fire control imagery, there is a need to design and construct an image quality testing tool for the HMD. The objective of this study is to propose and test a design concept for an image quality tester for HMD subsystems. The tester can be used as a validation tool to verify settings for regular flight missions and for preventive maintenance tasks. The first prototype tester will be designed for the AH-64's IHADSS HMD.

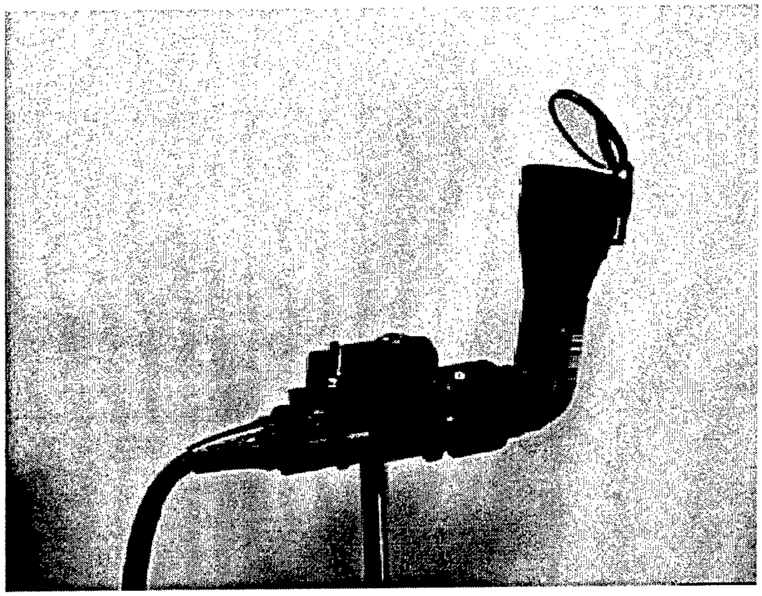

Figure 2. The IHADSS HDU.

Functionality and operating process

The proposed tester will allow pilots and maintenance personnel to validate the image quality of an HMD. Basic required characteristics include (1) simple design, (2) ease of use, (3) robustness, and (4) accuracy for operations and maintenance. The prototype should be small enough to fit into a brief case, which would include a lap-top, image capture system, and power supply pack.

The IHADSS HMD has a monocular 30-degree vertical by 40-degree horizontal field-of-view (FOV). Future HMDs most likely will have larger FOVs and be binocular in design. HMD corner obscurations are generally permissible and symmetrical for the IHADSS, as illustrated in Figure 3. Since hardware changes to the various aircraft electronics will not be allowed, image quality validation must be performed using manufacturer built-in test patterns. The built-in test pattern of the IHADSS HMD is used as the inspection specification on which the first tester will be based. The test pattern shows strips of gray opposed along the vertical center lines. Each strip contains 8 to 10 shades of gray, depending on the contrast ratio. Adjacent shades have a square root of 2 differential of brightness. Figure 4 is a snapshot of the test pattern captured from the IHADSS HMD. For more detailed discussion of the HMD test pattern features, see the Honeywell, Inc. study guide (1985) and Harding et al. (1995). For testing this test pattern, the inspection features used by the image quality tester prototype will include (1) four vertical center lines, (2) one horizontal center line, (3) two gray shade patterns (with 8 to 10 shades), and (4) a boundary box.

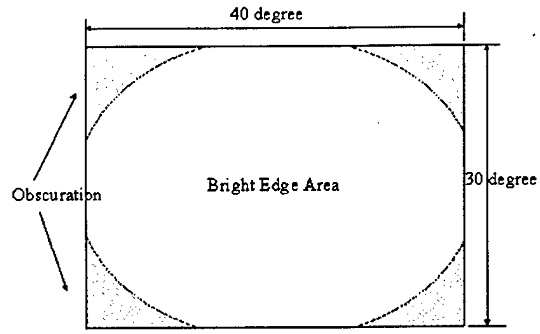

Figure 3. Display size.

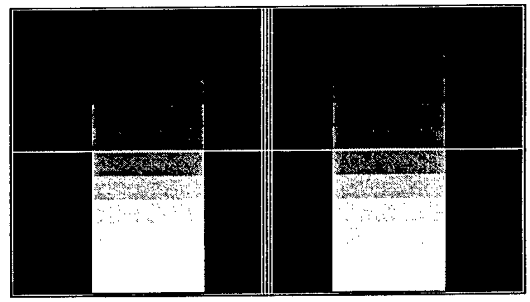

Figure 4. Test pattern from the IHADSS HMD.

Based on the design objectives and inspection procedures, the tester operation procedures are as follows: (1) the pilot adjusts the HMD settings and passes the HDU to the crew chief; (2) the crew chief inserts the HMD into a fixture; (3) the system examines the center and horizontal line features of the test pattern using a narrow-angle lens; (4) the system inspects the test pattern for image displacement and/or disorientation; (5) the system examines the number of gray-shades, the focus, luminance, and boundary lines, using a 42-degree wide-angle lens; and (6) the system generates a final report. Figure 5 shows a flow chart for the proposed operation procedures.

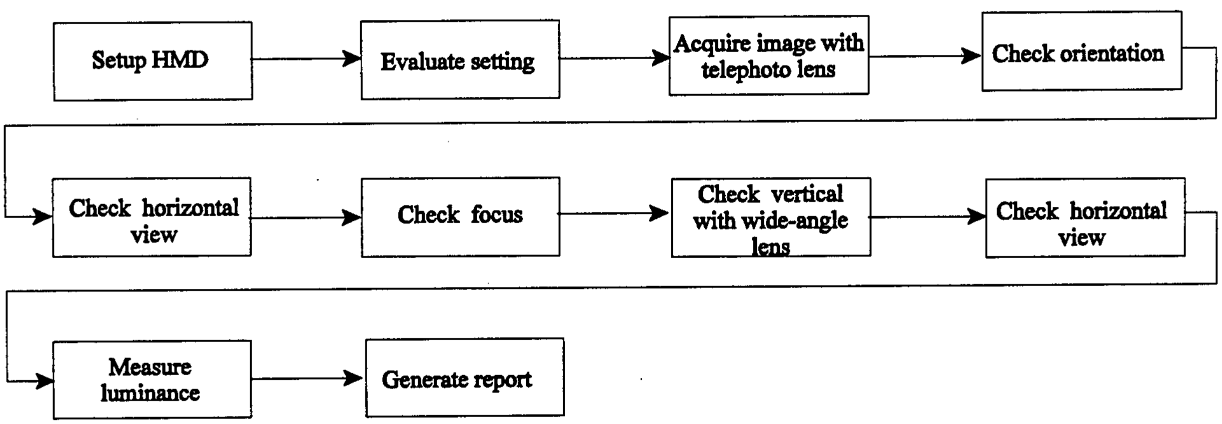

Figure 5. Flow chart for HMD prototype tester operation.

Methodology

This study involved designing and testing (1) the hardware specification for image capture, (2) the test pattern inspection features, (3) the software prototype, and finally (4) the hardware prototype. Experiments and statistical analysis tools were applied throughout the design process.

Image capture hardware specifications

To determine the needed camera and lens specification for test pattern image capture, experiments were conducted to verify the sensitivity of a candidate camera. The camera and a Photo Research (Appendix A) model 1980 photometer were mounted using a reconfigurable optical fixture and bench accessories and were used to capture an electronically generated gray shade test pattern. Figure 6 illustrates the experimental setup. The luminance of the test pattern image was registered by the charged couple device (CCD) camera (and image capture card) and the photometer. Figure 7 shows the locations where data were sampled from the test pattern. These data were measured from a fixed position along a horizontal line across the entire test pattern. Three measurements were taken from each region. An observation resulting from the experiment was that the luminances of the gray shades presented in the test pattern were not linearly distributed between 0 and 255. The differential of luminance for adjacent shades was greater than an approximate square root of 2. A statistical analysis was performed on these data. Results indicated that the luminance levels measured by the photometer were consistent with data from the camera and image capture card up to and including the 7th gray shade. It can be seen that the CCD saturated after the 7th gray shade area. To prevent this, the aperture of the CCD would have to be adjusted. If only the first seven gray shades are used in the analysis, correlation is 0.98. The table and Figure 8 record the data collected from both instruments and the statistical analysis results.

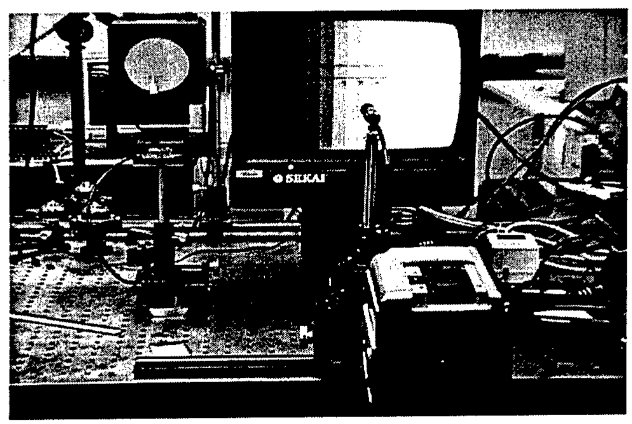

Figure 6. Experimental setup for camera sensitivity analysis.

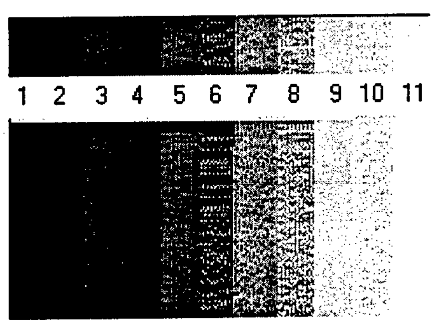

Figure 7. Sampling locations on the test pattern.

Table.
Measured data and correlation coefficient from photometer and CCD camera.

Gray shade	Photometer luminance readings			CCD gray level readings		
1	3.25	3.32	3.35	7	7	7
2	7.47	7.51	7.46	25	25	25
3	17.07	16.99	16.99	65	65	65
4	30.51	30.54	30.43	99	99	99
5	48.28	48.24	48.12	146	146	146
6	71.9	71.86	71.81	194	194	194
7	98.35	98.54	98.67	227	227	227
8	127.1	127.2	127.3	230	230	230
9	157.9	158.1	158.0	235	235	235
10	187.4	187.4	187.1	240	240	240
11	221.2	221.4	221.2	242	242	242
12	200.7	200.6	200.6	237	237	237
Luminance vs gray level (7 shades): Correlation = 0.983886; Fisher's z = 2.406549; Probability = 00006						

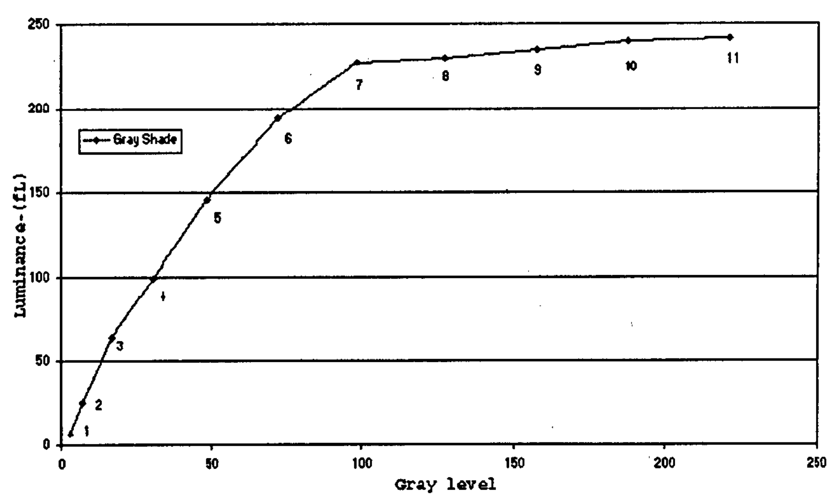

Figure 8. Plot of photometer and CCD camera data.

In an attempt to capture the test pattern image on the IHADSS fully, several different cameras (with standard lenses) were evaluated. However, although the full test pattern could be captured, the details of the four vertical center lines could not be differentiated. Therefore, a decision was made to use a narrow angle lens to zoom in on the center area of the test pattern in order to capture the details of the center lines. HMDs are also used at night; therefore, the prototype tester--specifically the camera--should provide good sensitivity at low luminance levels. First order specifications for the required camera were summarized as follows:

1. Sensitivity: ≤ 0.005 lux
2. Focus: To infinity
3. Resolution: > 768 x 498 pixels
4. Focal length: ~½ inch
5. Iris: Manual
6. Fields of view: >40 (H) x 30 (V) degrees and ~5 x 3 degrees

Test pattern features investigation

An additional experiment was conducted to investigate various aspects of capturing the test pattern. Multiple cameras were used since a single camera that met all the desired specifications was not available at the time of this study. Aspects of interest included the size of the pattern, number of different features, relative luminance ratios among features, spatial content of each feature, and number of gray shades. The IHADSS HMD was mounted on the top of the optical post, and the post was fixed on top of a round optical table controlled by a programmable position table. The table was driven by a stepping motor with an accuracy of 1 micron (μm). The test pattern image was projected onto a video monitor for observation. Figure 9 shows the experimental setup. The entire test pattern image from the HMD was captured and constructed through a series of mini steps in the horizontal and vertical directions. The overall picture was approximately 38 x 29 degrees, which was close to the specification in the study guide (Honeywell, Inc.,1985). The center line occupied approximately 0.5 degree out of 38 degrees. There were two strips with 10 to 12 gray shades mirrored opposite the center lines. Figure 10 shows the structure of the IHADSS test pattern. A series of images were taken to probe the content of each gray shade in terms of luminance. Based on the observed information, a series of image files was constructed and used as an image profile for purposes of the software prototype development. Figure 11 displays this replicated test pattern image.

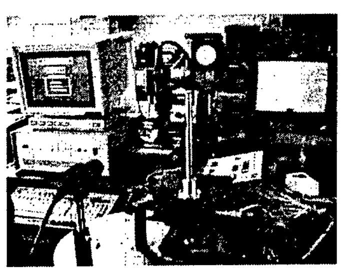

Figure 9. Setup for test pattern measurement.

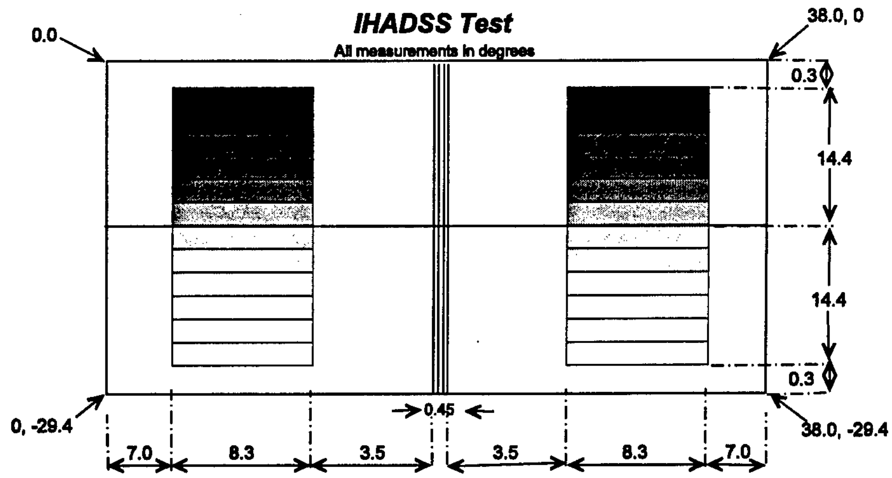

Figure 10. Test pattern design based on measurement results.

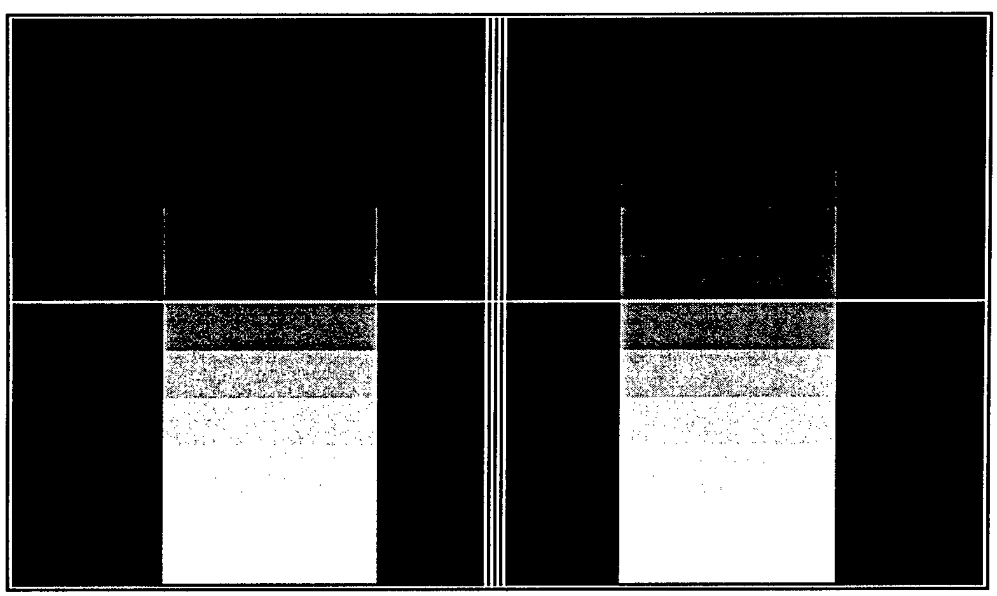

Figure 11. Replicated test pattern image.

A similar experiment was conducted to detail the center lines within the test pattern. Figure 12 shows the luminance scan measurements for the center lines. The four peaks represent the four center lines which are spread out over 0.8 degree from valley to valley and 0.4 degree peak to peak. The average peak width is about 0.0969 degree and the average distance between peaks is about 0.1347 degree. Note: A measurement of 1 degree is about 485 μm in the object plane.

Another experiment was conducted to probe the state of the center lines when the HMD is in focus and not in focus. Varied focus values of -1 to 1 diopter of CRT were applied. Measure-

ments of the four vertical center lines were taken. An interesting finding was, when the HMD was in focus, the ratio of luminances between bottom to mid-peak (B) and peak to valley (A) was close to 1. However, when the setting was not in focus, the B:A ratio was less than one. Figure 13 documents these observations and illustrates the concept. Findings from the above experiments, such as measurements, luminance ratios, and the content of each feature within the test pattern, were used to create a test pattern image using graphics software. Figure 14 shows an image of such a test pattern using a 5 X 4 degree lens to focus on the center lines of the test pattern. In addition, the ratio of the square root of 2 luminance difference was used to design gray shades ranging from 0 to 255 gray levels.

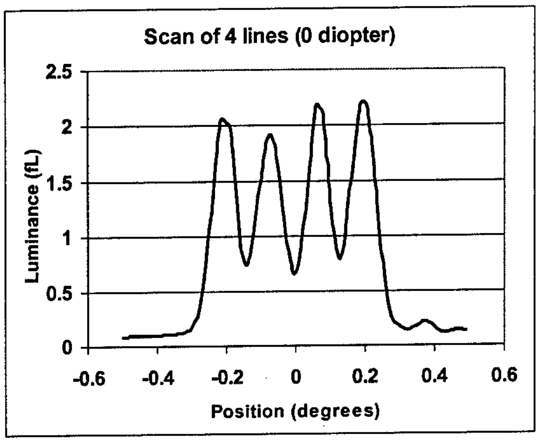

Figure 12. Measurement of luminance of the center lines.

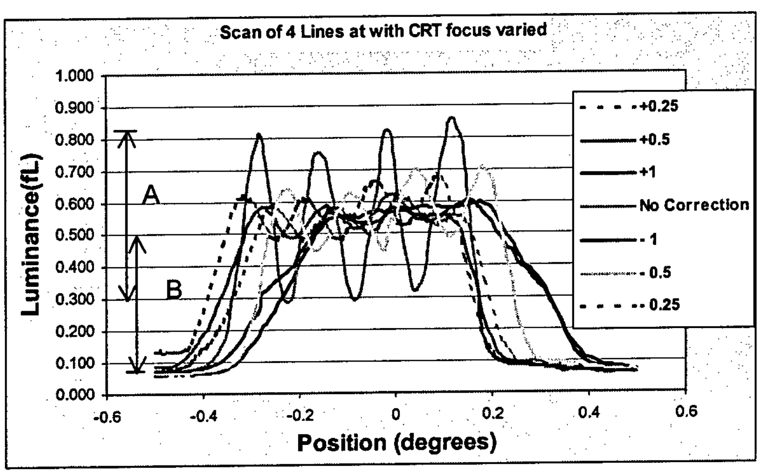

Figure 13. Center lines measurement with varied focus.

To emulate potential human errors in setting up the HMD, a set of parameters (including brightness, orientation, spatial adjustment, and contrast) were manipulated and the resulting images captured. These images were used as a basis for creating new image files. These designed images

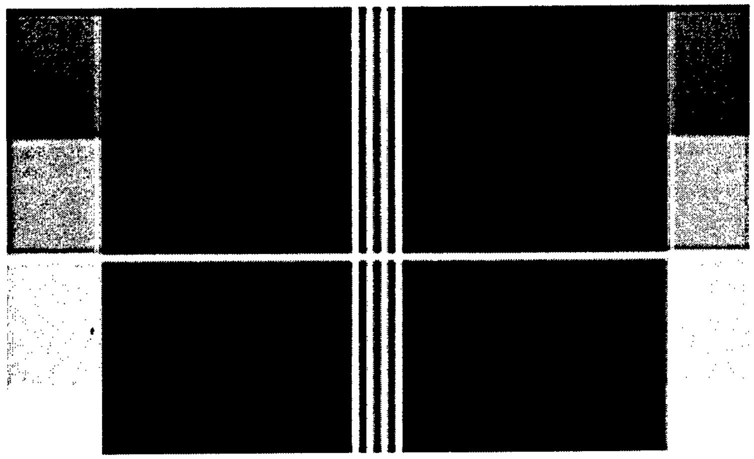

Figure 14. Designed test pattern with focus on the center lines.

were used to test the software prototype. The experiments were carried out using similar methods. For example, to measure the potential displacement of the test pattern, a camera was mounted facing the HMD. The test pattern was projected onto a video monitor by means of a personal computer (PC). Measurements were taken before and after the spatial adjustments. The maximum adjustments in the upward, downward, left and right directions were 3.57, 2.98, 4.90 and 4.90 degrees, respectively, based on an FOV of 40 x 31 degrees (Harding et al., 1995).

Software prototype design

The software prototype was designed to capture, analyze, and interpret the image against test pattern features such as the four center lines and number of gray shades. Accordingly, the prototype design will require three modules--image acquisition, image analysis and interpretation--as well as on-line user help. Figure 15 shows the modules involved in the prototype. Visual Basic (VB) was used to develop the prototype because of its flexibility in linking and embedding with other commercial software and because it was a powerful toolbox for rapidly prototyping a complicated window. In the following sections, we describe the functionality of each module and how the modules are integrated. Algorithms developed to interpret the image follow. Finally, testing and validation of the code is addressed. The source code for the program can be found in Appendix B.

Image capture module

The VB Object Linking and Embedding (OLE) capability allows integration of other programs. In this case, the image capture graphics program served as an object which was linked into the VB main program. The graphics program was launched by activating the linked object. Once the object had been activated, the VB main program allowed the user to modify, save, or open documents created by the graphic program in VB's integrated design environment (IDE). After the user was done with the image capture graphics program, control was released to the VB environment. The graphics program itself contained three components: the driver used to activate the image capture card and digitize the video signal into a graphics image format (e.g., bitmap or jpeg); an image processing shell which allowed image manipulation (e.g., sharpening and

lightening); and an on-line user manual. Figure 16 shows the opening screen for the image capture module. Figures 17 and 18 show image capture and processing subcomponents.

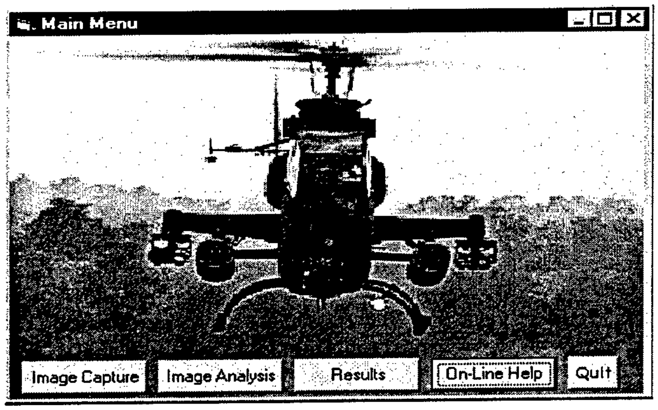

Figure 15. Opening screen of prototype software.

Figure 16. Image capture module.

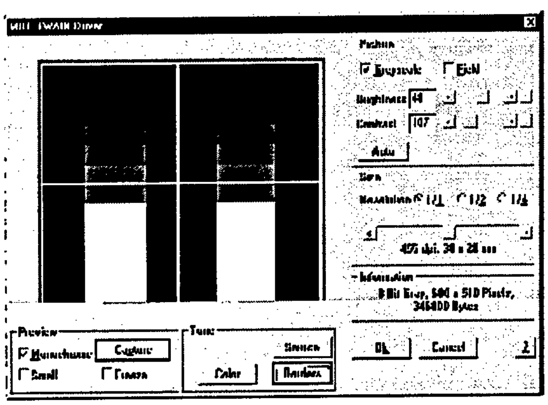

Figure 17. Image capture component.

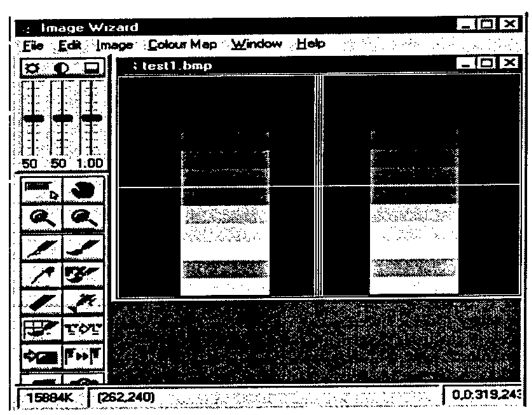

Figure 18. Image processing component.

Image analysis and interpretation module

The image analysis and interpretation module (1) detects the presence of key features such as center lines within the test pattern, (2) compares selected features against the feature specification, and (3) generates findings. VB components were created to provide these functions and to interface with other modules. A subwindow titled "evaluation criteria" was created to analyze and interpret the captured image from an HMD. A few created algorithms were coded in VB to perform the analysis. Other subwindows, such as a directory box and file list boxes were created to allow retrieval of image files for analysis. Finally, an additional subwindow was designed to display the image currently being analyzed. This module also allows access to other modules via a button control. Figure 19 shows the image analysis and interpretation module.

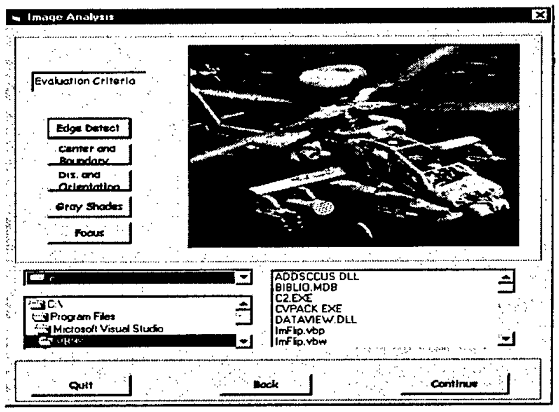

Figure 19. Image analysis and interpretation module.

Algorithm design

Algorithms were developed to detect various features within the test pattern as described earlier. These are described below:

A. Identify the number of center lines.

Step 1. Apply binary image technique to the entire image.
Step 2. Draw multiple lines across X and/or Y axes.
Step 3. Identify mask with feature of B/W. . . W/B.
Step 4. Store the intersection points in an array with multiple dimensions.
Step 5. Construct regression lines based on the points within each dimension.
Step 6. Develop regression lines to compare the parallel property.
Step 7. Average the intersection points around the array to obtain the number of estimated lines.

Note 1: B = black pixel and W = white pixel.
Note 2: Use of linear regression analysis would make the linear mode robust and insensitive to noise presence.

B. Identify the center point.

Step 1. Construct a regression line based on all the intercepted points.
Step 2. Identify the midpoint of an array as a starting point with the feature of W/B/W.
Step 3. Examine neighboring pixels to see if a W/W/W mask exists.
Step 4. If a W/W/W mask exists, stop the procedure; else next step.
Step 5. Check the distance of neighboring pixels from the regression line using a 3 x 3 area.
Step 6. Select the point with the smallest distance from the regression line as the next point.
Step 7. Go to step 3.

C. Identify test pattern orientation and displacement.

Step 1. Compute a theoretical center as point A.
Step 2. Identify the actual center point (based on part B) as point B.
Step 3. Compute the distance between point A and B as d.
Step 4. If d is equal to 0; then the displacement is zero.
Step 5. Construct lines between a given point with points A and B.
Step 6. Compute the angle between lines as orientation angle

D. Identify the number of gray shades within a test pattern.

Step 1. Use the center point as a starting point.
Step 2. Pick five points across the center line that are within the boundary of gray shades.
Step 3. Compute the average gray level of the five points.
Step 4. Store it in one dimension of the array.
Step 5. If the boundary is not reached, move up or down a given distance, and go to Step 3; else next.
Step 6. Use of square root of two differences to determine the number of gray shades.

E. Identify boundary lines.

Step 1. Use the center point and boundary ratio to determine the region of the image boundary.
Step 2. Locate a starting point white pixel to use for back tracking the rest of the white pixels for each line segment.

F. Identify the focus setting.

Step 1. Use line scan technique to record the pixels along the center lines.
Step 2. Use the B/W/B mask to identify the separation of lines.
Step 3. Compute the ratio of bottom to mid-peak and peak to valley for all four lines.
Step 4. If the ratio is approximately one, we may conclude that the focus setting is good; or else check the focus setting.

Other methods for center point detection exist. However, these were deemed less appropriate for this application. For instance:

Alternate approach #1:

b b b b
Step 1. Use of the mask of bwwwwwb
b b b b

Note: If the orientation of the image is unknown, this method can be time consuming.

Alternate approach #2:

Step 1. Find the center point of each line.
Step 2. Use the averaging method to find the center of all the centers.

Note: This method involves more steps than the proposed one, because you must first find the center of each line and there are four lines to be examined.

Alternate approach #3:

Step 1. Identify the boundary of the image.
Step 2. Use the center of gravity method to find the center of the image.

Figure 20(a-d) shows screens from the image analysis module. Figure 20a shows a binary image of the test pattern after the binary image technique had been applied to the test pattern captured from the HMD. Figure 20b shows the four center lines that were identified from the binary image (Figure 20a). After the center lines had been identified, the image analysis module identified the center point of the image. Figure 20c shows the coordinates (y only shown) of the center point. The image analysis module then determined if the image was tilted or not. Figure 20d displays the tilt angle of the image. The analysis results are summarized and displayed in Figure 21. A primary feature of the image analysis module is to identify features present in the captured test pattern. The "Sober operator," a well known edge detection technique, is used to identify the boundaries of the features and, thereby, allow the analysis module to determine whether or not the required features are present in the captured test pattern image. Figure 22 shows the same image before and after the Sober operator is applied.

Testing and validation

To verify the accuracy of the program, language debugging tools, and split-half and back tracking strategies were imposed throughout the coding process. The program results were compared with the simulation results. For example, to check the accuracy of the constructed regression line, the same data points also were analyzed and compared with the results obtained from a statistics package and hand calculation.

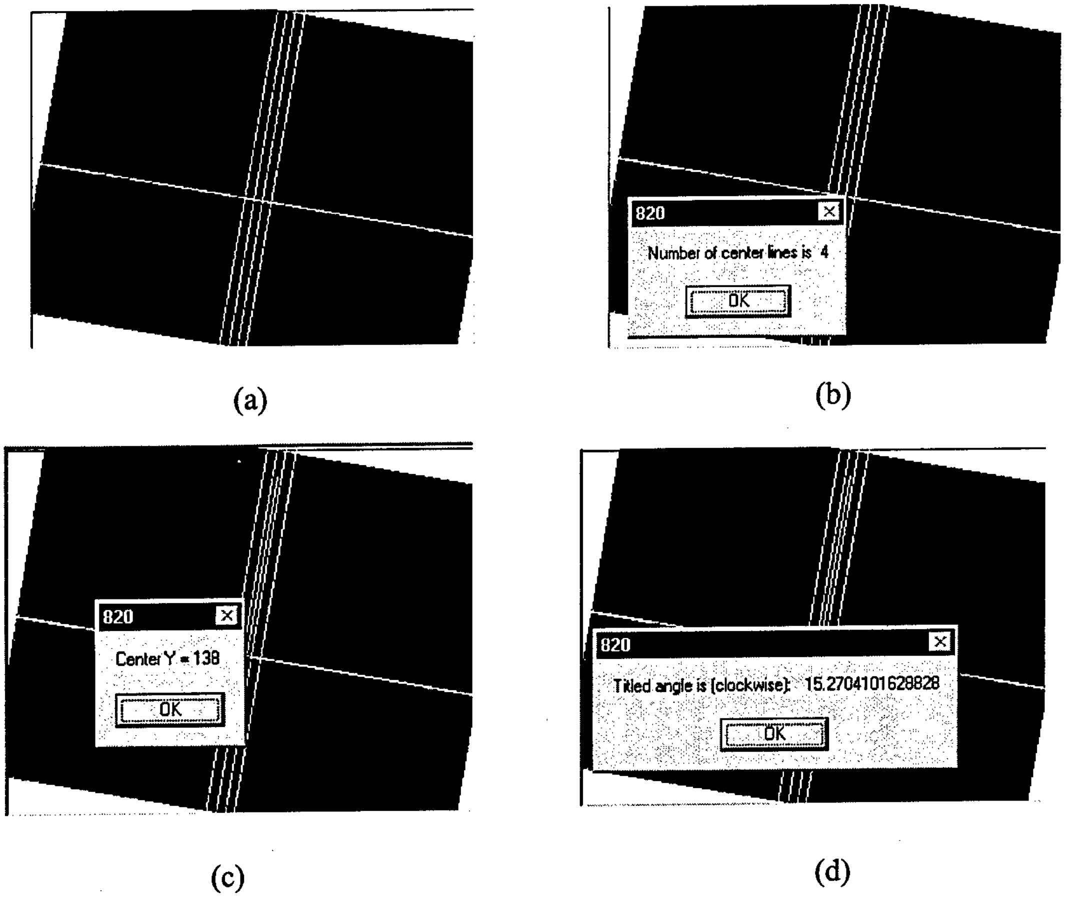

Figure 20. Tilted test pattern binary images from image analysis module.

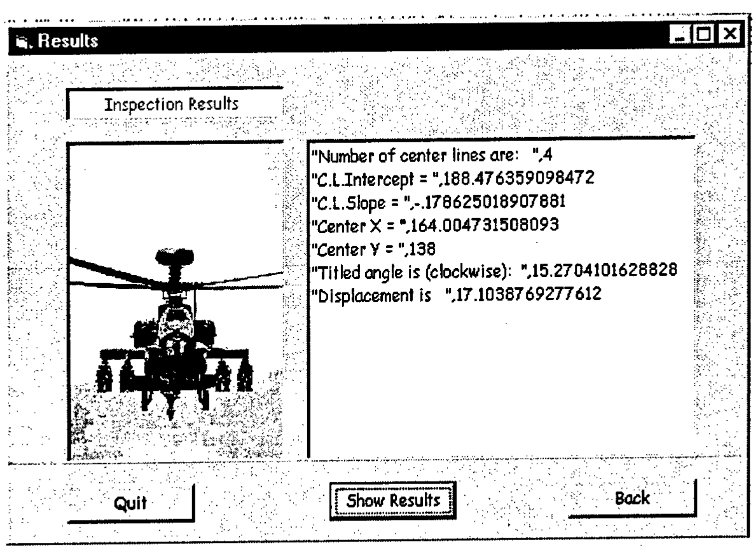

Figure 21. Overall testing results of an HMD.

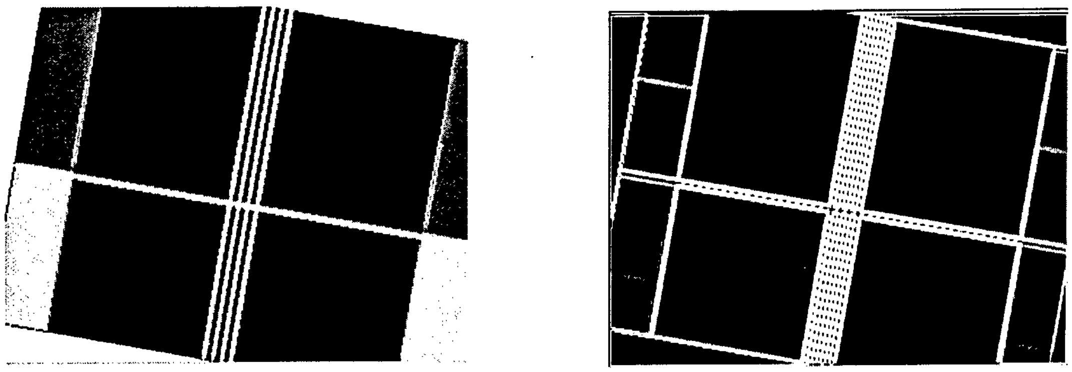

Figure 22. Tilted test pattern before (left) and after (right) Sober edge detection.

Hardware package design

A preliminary concept for the hardware package design consists of a display/output module, power supply module, and image capture module. The display/output module should be designed to display/generate inspection results of an HMD test pattern. The power supply module should be designed to provide the voltages needed for the cameras and computer. The design also should include a rechargeable battery pack which will allow the unit to operate in areas without an external power supply. The power supply would be required to provide 12- and 9-volt outputs for the cameras and computer, respectively. Finally, the image capture module must be designed to hold an HMD and two cameras in fixed and contained positions, thereby preventing potential noise that may affect the inspection accuracy. A proposed design is as follows: Two cameras arranged vertically and facing the HMD. [Figure 23 shows one method investigated for aligning the CCD image capture cameras and the HMD.] An inverted HMD fixture will be the most likely one be used in the final concept. The fixture would be mounted with spring return locks on the sides and bottom. The spring return locks will lock the HMD in a fixed position. These locks would prevent the inspection process from continuing if the HMD is not positioned correctly. Once the HMD is in the correct position, a proximity sensor will be used to trigger the image system to start the image capture and interpretation processes. The cover of the image capture module is in the shape of an inverted HMD. It is designed to cover the HMD tightly once it is in the correct position, and to eliminate any optical noise from the surrounding environment. To enhance the speed of image analysis, an Electronic Programmable Read Only Memory (EPROM) chip, custom programmed to load the executable program for image analysis, could be used. Figure 24 illustrates a preliminary computer aided design (CAD) concept of the hardware prototype design.

Conclusions and future directions

In this project, a design framework for an image quality tester was proposed and evaluated. Functionality and requirements of the tester were identified. Experiments were conducted to test

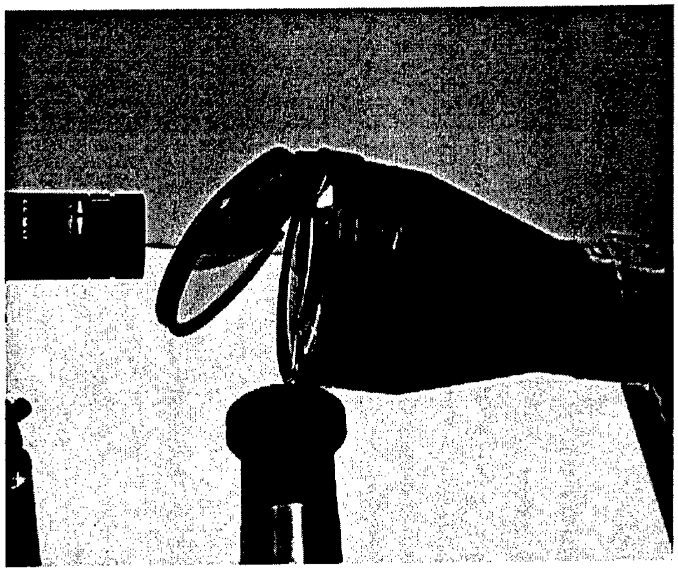

Figure 23. Investigation of CCD image capture arrangement.

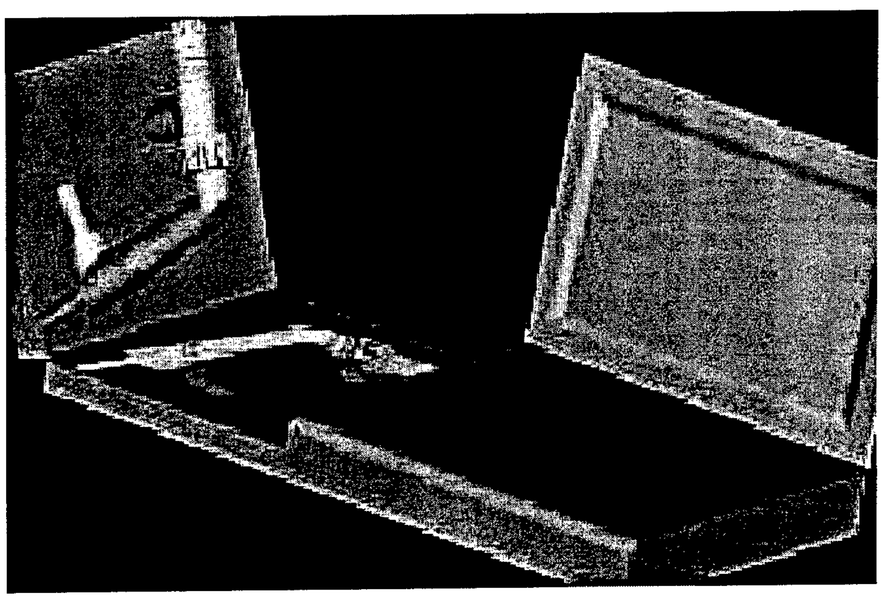

Figure 24. CAD concept of prototype hardware design.

camera sensitivity and to probe aspects of an HMD test pattern using programmable micro-positioning systems and a CCD camera. Test pattern specifications were developed based on these observations. A strategy for image analysis and interpretation was formed, and algorithms were designed to verify the test pattern of a given HMD against the specifications. A prototype software

package was written to inspect the test pattern and verify the effectiveness of the algorithms. Finally, a design framework for a concept hardware package was proposed.

To build a brassboard version of a tester, future work must include: (1) fabrication of the hardware design using inverse casting techniques, (2) integration of software and hardware components for a prototype design, (3) field testing of the prototype, (4) incorporation of learning algorithms to increase inspection accuracy, and (5) expansion of functionality from validation to on-line real time interactive adjusting and self-tuning based on a given environmental scenario. From the maintenance perspective, the work can be expanded to self-diagnosis and preventative maintenance (such as life-time prediction).

<u>References</u>

Avionics Systems Group, Military Avionics Division. 1985. <u>Integrated Helmet and Display Sighting System - Study Guide</u>. St. Louis Park, MN: Honeywell, Inc.

Harding, T.H., Beasley, H.H., Martin, J.S. and Rash, C.E. 1995. <u>Physical Evaluation of the Integrated Helmet and Display Sighting System Helmet Display Unit</u>. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 95-32.

Appendix A.

List of manufacturers.

Photo Research
3000 North Hollywood Way
Burbank, CA 91505

Appendix B

Software prototype program.

Form1 - 1

```
Private Sub Timer1_Timer()

Dim PauseTime, Start

    PauseTime = 2    ' Set duration.
    Start = Timer    ' Set start time.
    Do While Timer < Start + PauseTime
        DoEvents     ' Yield to other processes.
    Loop
        Unload Me
    Form2.Show

End Sub
```

Form2 - 1

```
Private Sub cmdQUIT_Click()

Unload Form2
End

End Sub

Private Sub Command2_Click() 'Image Analysis

    Unload Form2
    Form4.Show

End Sub


Private Sub Command1_Click() 'Image Capture

    Unload Form2
    Form3.Show

End Sub

Private Sub Results_Click()

    Unload Form2
    Form5.Show

End Sub
```

Form3 - 1

```
Private Sub Continue_Click()

Unload Form3
Form4.Show

End Sub

Private Sub Quit_Click()

Unload Form3
Form2.Show

End Sub
```

```
Public Displacement, Angle As Double
Public CenterLineSlope As Double
Public CenterLineIntercept As Double
Public Center_Point_X, Center_Point_Y As Double

Const intUpperBoundX = 320  '320 total
Const intUpperBoundY = 244  '244 total
Const N = 4 '# of center line

Dim X, Y As Integer
Dim picObject0, picObject1 As Picture
Dim Coord_X(0 To 45, 0 To 10) As Integer
Dim Coord_Y(0 To 45, 0 To 10) As Integer
Dim pixels(0 To intUpperBoundX, 0 To intUpperBoundY) As Long
Dim ImagePixels(2, intUpperBoundX, intUpperBoundY) As Integer
Private Sub cmdSelect_Click()

Dim FileName, EdgeDetection As String
Dim bytRed, bytGreen, bytBlue, bytAverage As Integer

On Error GoTo FileError
If (Right$(Dir1.Path, 1) = "\") Then
   FileName = File1.Path & File1.FileName
 Else
   FileName = File1.Path & "\" & File1.FileName
End If

Open FileName For Input As #1
Set picObject0 = LoadPicture(FileName)
Set Picture0.Picture = picObject0
Close #1

For X = 0 To intUpperBoundX - 1
   For Y = 0 To intUpperBoundY - 1

      pixels(X, Y) = Picture0.Point(X, Y)
      bytRed = GetRed(pixels(X, Y))
      bytGreen = GetGreen(pixels(X, Y))
      bytBlue = GetBlue(pixels(X, Y))

      ImagePixels(0, X, Y) = bytRed
      ImagePixels(1, X, Y) = bytGreen
      ImagePixels(2, X, Y) = bytBlue

      'the file u have is in gray scale; therefore, u do not need to average
      Picture0.PSet (X, Y), RGB(bytRed, bytGreen, bytBlue)

   Next Y
Next X

Exit Sub

FileError: MsgBox "File Error!"

End Sub

Private Sub cmdCenter_and_Boundary_Click()

Set Picture0.Picture = picObject0
For X = 0 To intUpperBoundX - 1
   For Y = 0 To intUpperBoundY - 1
      Picture0.PSet (X, Y), Picture0.Point(X, Y)
   Next Y
Next X

Set picObject1 = Picture0.Picture
SavePicture picObject1, "TEST1.BMP"
LoadPicture ("TEST1.BMP")
```

```
Form4 - 2

End Sub

Private Sub cmdEdgeDetection_Click()

Dim RGBLong As Long
Dim G_X, G_Y, G_X_Y As Integer
Dim bRXY, bRXm1Y, byRXYm1, bRXm1Ym1 As Integer
Dim bRXp1Y, bRXYp1, bRXp1Yp1, bRXp1Ym1, bRXm1Yp1 As Integer
Dim bytRed, bytGreen, bytBlue As Integer

Set Picture0.Picture = picObject0

For X = 0 To intUpperBoundX - 1
   For Y = 0 To intUpperBoundY - 1

     If (X = 0 Or X = intUpperBoundX - 1 Or Y = 0 Or Y = intUpperBoundY - 1) Then

        bytRed = ImagePixels(0, X, Y)
        bytBlue = ImagePixels(1, X, Y)
        bytGreen = ImagePixels(2, X, Y)
        RGBLong = RGB(bytRed, bytGreen, bytBlue)

        Picture0.PSet (X, Y), RGBLong

     Else

      G_X = 0
      G_Y = 0
      G_X_Y = 0

      bRXY = ImagePixels(0, X, Y)
      bRXYp1 = ImagePixels(0, X, Y + 1)
      bRXm1Y = ImagePixels(0, X - 1, Y)
      bRXYm1 = ImagePixels(0, X, Y - 1)
      bRXm1Yp1 = ImagePixels(0, X - 1, Y + 1)
      bRXm1Ym1 = ImagePixels(0, X - 1, Y - 1)
      bRXp1Y = ImagePixels(0, X + 1, Y)
      bRXp1Ym1 = ImagePixels(0, X + 1, Y - 1)
      bRXp1Yp1 = ImagePixels(0, X + 1, Y + 1)

      G_X = bRXp1Ym1 + 2 * bRXp1Y + bRXp1Yp1 - bRXm1Ym1 - 2 * bRXm1Y - bRXm1Yp1
      G_Y = bRXm1Yp1 + 2 * bRXYp1 + bRXp1Yp1 - bRXm1Ym1 - 2 * bRXYm1 - bRXp1Ym1
      G_X_Y = Sqr((G_X * G_X) + (G_Y * G_Y))

      bytRed = G_X_Y

      bRXY = ImagePixels(1, X, Y)
      bRXYp1 = ImagePixels(1, X, Y + 1)
      bRXm1Y = ImagePixels(1, X - 1, Y)
      bRXYm1 = ImagePixels(1, X, Y - 1)
      bRXm1Yp1 = ImagePixels(1, X - 1, Y + 1)
      bRXm1Ym1 = ImagePixels(1, X - 1, Y - 1)
      bRXp1Y = ImagePixels(1, X + 1, Y)
      bRXp1Ym1 = ImagePixels(1, X + 1, Y - 1)
      bRXp1Yp1 = ImagePixels(1, X + 1, Y + 1)

      G_X = bRXp1Ym1 + 2 * bRXp1Y + bRXp1Yp1 - bRXm1Ym1 - 2 * bRXm1Y - bRXm1Yp1
      G_Y = bRXm1Yp1 + 2 * bRXYp1 + bRXp1Yp1 - bRXm1Ym1 - 2 * bRXYm1 - bRXp1Ym1
      G_X_Y = Sqr((G_X * G_X) + (G_Y * G_Y))

      bytBlue = G_X_Y

      bRXY = ImagePixels(2, X, Y)
      bRXYp1 = ImagePixels(2, X, Y + 1)
      bRXm1Y = ImagePixels(2, X - 1, Y)
      bRXYm1 = ImagePixels(2, X, Y - 1)
      bRXm1Yp1 = ImagePixels(2, X - 1, Y + 1)
      bRXm1Ym1 = ImagePixels(2, X - 1, Y - 1)
      bRXp1Y = ImagePixels(2, X + 1, Y)
```

```
      bRXp1Ym1 = ImagePixels(2, X + 1, Y - 1)
      bRXp1Yp1 = ImagePixels(2, X + 1, Y + 1)

      G_X = bRXp1Ym1 + 2 * bRXp1Y + bRXp1Yp1 - bRXm1Ym1 - 2 * bRXm1Y - bRXm1Yp1
      G_Y = bRXm1Yp1 + 2 * bRXYp1 + bRXp1Yp1 - bRXm1Ym1 - 2 * bRXYm1 - bRXp1Ym1
      G_X_Y = Sqr((G_X * G_X) + (G_Y * G_Y))

      bytGreen = G_X_Y

      Picture0.PSet (X, Y), RGB(bytRed, bytGreen, bytBlue)

    End If

   Next Y
Next X

End Sub
Private Sub cmdGray_Shade__Click()


Set Picture0.Picture = picObject0
For X = 0 To intUpperBoundX - 1
   For Y = 0 To intUpperBoundY - 1
        Picture0.PSet (X, Y), Picture0.Point(X, Y) - 5
   Next Y
Next X

End Sub
Private Sub cmdFoucs_Click()

Set Picture0.Picture = picObject0
For X = 0 To intUpperBoundX - 1
   For Y = 0 To intUpperBoundY - 1
        Picture0.PSet (X, Y), Picture0.Point(X, Y) - 10
   Next Y
Next X

End Sub
Private Sub cmdDis_and_Orientation_Click()
Const interval_range = 7

Dim WhitePixel, BlackPixel As Long
Dim linescan As Integer
Dim i, j, k, L, IntX, Temp_X, Temp_Y As Integer
Dim Flag, SumTline, Dummy As Integer
Dim interval As Integer
Dim ZeroO_X, ZeroO_Y As Double
Dim L1SlopeR, L2SlopeR, L3SlopeR, L4SlopeR, L1SlopeY, _
    L2SlopeY, L3SlopeY, L4SlopeY, AvgSlope As Double

Dim UpperBound, LowerBound As Double
Dim InterceptY As Integer
Dim Count_Points(0 To 403) As Integer
Dim TempInt, Choice As Integer
Dim Dum(0 To 15) As Double
Dim TempDouble As Double
Dim Tline(0 To 50) As Integer
Dim Oripixels(0 To intUpperBoundX, 0 To intUpperBoundY) As Long

Dim Displacement, Angle, Theta As Double
Dim CenterLineSlope As Double
Dim CenterLineIntercept As Double
Dim Center_Point_X, Center_Point_Y As Double
Dim TempText As String

Open "c:\windows\desktop\InspResults.txt" For Output As #1

For X = 0 To intUpperBoundX - 1
 For Y = 0 To intUpperBoundY - 1
```

```
   Oripixels(X, Y) = pixels(X, Y)
  Next Y
Next X

'Apply the binary image technique

For X = 0 To intUpperBoundX - 1
 For Y = 0 To intUpperBoundY - 1
   If (Oripixels(X, Y) < RGB(255, 255, 255)) Then
        Oripixels(X, Y) = 0
   Else
        Oripixels(X, Y) = RGB(255, 255, 255)
   End If
   Picture0.PSet (X, Y), Oripixels(X, Y)

 Next Y
Next X

'Find the number of center lines
'A line is BW...WB; if there is less than four BW...WBs; then Image is tilled
'white interval should be less than 7 for the central lines
'use Black/White/Black to find a line

linescan = 0
interval = 1

For Y = 50 To intUpperBoundY - 1
   Tline(linescan) = 0
   Flag = 0
   L = 0

   For X = 0 To intUpperBoundX - 1
      If ((Oripixels(X, Y) = RGB(0, 0, 0)) And _
      (Oripixels(X + 1, Y) = RGB(255, 255, 255))) Then

         For interval = 1 To interval_range - 1
           If (Oripixels(X + 1 + interval, Y) = RGB(0, 0, 0)) Then

                Tline(linescan) = Tline(linescan) + 1
                Flag = 1

                Coord_X(linescan, L) = X + 1              'of each line
                Coord_Y(linescan, L) = Y

                L = L + 1

           End If
           interval = interval_range 'stop the for loop
         Next interval
      End If
   Next X
   Y = Y + 10 ' 5         'to have 40 arbitary verticle lines
   If (Flag = 1) Then
   linescan = linescan + 1
   End If
 Next Y

 k = 0
 SumTline = 0
 For j = 0 To linescan - 1 'from prev. routine # of arb. ver. lines
  If (Tline(j) > 0) Then
     SumTline = SumTline + Tline(j)
     k = k + 1
  End If
 Next j

 If (3.5 <= (SumTline / k) <= 4.5) Then
    MsgBox ("Number of center lines is  " & N)
```

```
   L1SlopeR = GetSlope(linescan, 0, 0)
   L1SlopeY = GetSlope(linescan, 0, 1)

   L2SlopeR = GetSlope(linescan, 1, 0)
   L2SlopeY = GetSlope(linescan, 1, 1)

   L3SlopeR = GetSlope(linescan, 2, 0)
   L3SlopeY = GetSlope(linescan, 2, 1)

   L4SlopeR = GetSlope(linescan, 3, 0)
   L4SlopeY = GetSlope(linescan, 3, 1)

   AvgSlope = (L1SlopeY + L2SlopeY + L3SlopeY + L4SlopeY) / 4
   LowerBound = 0.025 * AvgSlope
   UpperBound = 1.025 * AvgSlope

'Use the absolute value; therefore, it works on both -/+ values

   If ((Abs(LowerBound) <= Abs(L1SlopeY) <= Abs(UpperBound)) And _
       (Abs(LowerBound) <= Abs(L2SlopeY) <= Abs(UpperBound)) And _
       (Abs(LowerBound) <= Abs(L3SlopeY) <= Abs(UpperBound)) And _
       (Abs(LowerBound) <= Abs(L4SlopeY) <= Abs(UpperBound))) Then
       MsgBox ("Four lines are parallel !")
   Else: MsgBox ("Potential errors in finding parallel lines")
   End If

Else
   MsgBox ("Number of center lines is  " & SumTline / k)
End If

'The following is to find the center point of the image
'Step 1: Find the black pixel
'Step 2: Calcuate the neighborhood pixels distance to the regression line
'Step 3: Locate the one that has the smallest distance
'Step 4: Check to see if the feature of w
'                                       wwww
'                                        W
' been meet
' if not; based on current X, Y; go to Step 1

BlackPixel = RGB(0, 0, 0)
WhitePixel = RGB(255, 255, 255)

CenterLineSlope = GetSlope(linescan, 0, 2)
CenterLineIntercept = GetSlope(linescan, 0, 3)

MsgBox ("C.L.Intercept = " & CenterLineIntercept)
MsgBox ("C.L.Slope = " & CenterLineSlope)

For Y = 20 To intUpperBoundY - 1
  X = (Y * CenterLineSlope) + CenterLineIntercept
    IntX = X
    If (Oripixels(IntX, Y) = BlackPixel) Then

       L = 0
       Temp_X = 0
       Temp_Y = 0
       For i = -1 To 1
            For j = -1 To 1
               If (Oripixels(IntX + i, Y + j) = WhitePixel) Then
                  Temp_X = Temp_X + (IntX + i)
                  Temp_Y = Temp_Y + (Y + j)
                  L = L + 1
               End If
               If (L >= 3) Then          'Neighborhood pixels are White
                  Center_Point_X = Temp_X / L
                  Center_Point_Y = Temp_Y / L
                  MsgBox ("Center X = " & Center_Point_X)
                  Beep
```

```
                    MsgBox ("Center Y = " & Center_Point_Y)
                    i = 1
                    j = 1
                    Y = intUpperBoundY
                 End If
              Next j
          Next i

          L = 0
          Dum(L) = 0
          For i = 0 To 1
             For j = 0 To 1
                If (i <> 0 Or j <> 0) Then
                  Dum(L) = Measure_Distance(CenterLineIntercept, CenterLineSlope, X + i, Y + j)
                  L = L + 1
                End If
             Next j
          Next i

          For k = 0 To L - 1
            If (Dum(k) < Dum(k + 1)) Then
              TempDouble = Dum(k)
              Dum(k) = Dum(k + 1)
              Dum(k + 1) = TempDouble
            End If
          Next k

          For i = 0 To 1
             For j = 0 To 1
                If ((i <> 0 Or j <> 0) And (Dum(L - 1) = Measure_Distance(CenterLineIntercept, Cent
erLineSlope, X + i, Y + j))) _
                  Then _

                    X = X + i
                    Y = Y + j - 1  'because Y auto. inc. by 1
                    i = 1
                    j = 1

                 End If
             Next j
          Next i

      End If
    Picture0.PSet (IntX, Y), RGB(255, 255, 255)

Next Y

'The following section is to find the orientation and displacement
'Comparing the theoretical zero point and new zero point
'Calculate the displacement and titled angle

ZeroO_X = (intUpperBoundX - 1) / 2
ZeroO_Y = (intUpperBoundY - 1) / 2

If ((Center_Point_X - ZeroO_X = 0) And (Center_Point_Y - ZeroO_Y = 0)) Then

    Theta = 0
    Displacement = 0

  Else

    Displacement = Sqr((Center_Point_X - ZeroO_X) ^ 2 + (Center_Point_Y - ZeroO_Y) ^ 2)
    TempDouble = (Center_Point_Y - ZeroO_Y) / Displacement
    Theta = Atn(TempDouble / Sqr(-TempDouble * TempDouble + 1))
    Angle = 90 - ((Theta / 3.141592654) * 180)

End If

MsgBox ("Titled angle is (clockwise):   " & Angle)
```

```
MsgBox ("Displacement is:    " & Displacement)

For X = 0 To intUpperBoundX - 1
 For Y = 0 To intUpperBoundY - 1
   Picture0.PSet (X, Y), RGB(255, 255, 255)
   Next Y
Next X

For i = 0 To 6

  Picture0.CurrentX = 20
  Picture0.CurrentY = 20 + 15 * i
  Select Case i
      Case 0:
         Picture0.Print ("Number of center lines are   " & N)
         TempText = "Number of center lines are:    "
         Write #1, TempText, N

      Case 1:
         Picture0.Print ("C.L.Intercept = " & CenterLineIntercept)
         Write #1, "C.L.Intercept = ", CenterLineIntercept

      Case 2:
         Picture0.Print ("C.L.Slope = " & CenterLineSlope)
         Write #1, "C.L.Slope = ", CenterLineSlope

      Case 3:
         Picture0.Print ("Center X = " & Center_Point_X)
         Write #1, "Center X = ", Center_Point_X

      Case 4:
         Picture0.Print ("Center Y = " & Center_Point_Y)
         Write #1, "Center Y = ", Center_Point_Y

      Case 5:
         Picture0.Print ("Titled angle is (clockwise):    " & Angle)
         Write #1, "Titled angle is (clockwise):   ", Angle

      Case 6:
         Picture0.Print ("Displacement is:    " & Displacement)
         Write #1, "Displacement is    ", Displacement

   End Select
 Next i
 Close #1

End Sub

Private Sub cmdQUIT_Click()

    Unload Form4
    Exit Sub
   ' Form2.Show

End Sub
Private Sub cmdBack_Click()

 Unload Form4
 Form3.Show

End Sub
Private Sub Dir1_Change()
    File1.Path = Dir1.Path
End Sub
Private Sub Drive1_Change()
    Dir1.Path = Drive1.Drive
End Sub
Function GetRed(colorVal As Long) As Integer
    GetRed = colorVal Mod 256
```

```
End Function
Function GetGreen(colorVal As Long) As Integer
    GetGreen = ((colorVal And &HFF00FF00) / 256&)
End Function
Function GetBlue(colorVal As Long) As Integer
    GetBlue = (colorVal And &HFF0000) / (256& * 256&)
End Function
Function GetSlope(Points As Integer, LineN As Integer, Choice As Integer) As Double

   Dim SumXY, SumX, SumY As Double
   Dim SumYsq, SumXsq, FuncDumy As Double
   Dim A, Index, Position_X, Position_Y As Integer

   SumXY = 0
   SumX = 0
   SumY = 0
   SumXsq = 0
   SumYsq = 0
   Position_X = 0
   Position_Y = 0
   Index = 0
   FuncDumy = 0

   'Sometimes the image is trancated; u do not have
   'all the 18 points; we use the B to represent to count
   'all the points
   'Choice 0: Line correlation coefficient
   'Choice 1: Parallel line slope
   'Choice 2: Center line slope
   'Choice 3: Center line intercept

  If (Choice = 0 Or Choice = 1) Then
     For A = 0 To Points - 1
       Position_X = Coord_X(A, LineN)
       Position_Y = Coord_Y(A, LineN)

       If ((Position_X <> 0) And (Position_Y <> 0)) Then
          SumXY = SumXY + (Position_X * Position_Y)
          SumX = SumX + Position_X
          SumY = SumY + Position_Y
          SumYsq = SumYsq + Position_Y ^ 2
          SumXsq = SumXsq + Position_X ^ 2
          Index = Index + 1
       End If
     Next A

  End If

 If (Choice = 2 Or Choice = 3) Then
     For A = 0 To Points - 1
      For LineN = 0 To N - 1
       Position_X = Coord_X(A, LineN)
       Position_Y = Coord_Y(A, LineN)

       If ((Position_X <> 0) And (Position_Y <> 0)) Then
          SumXY = SumXY + (Position_X * Position_Y)
          SumX = SumX + Position_X
          SumY = SumY + Position_Y
          SumYsq = SumYsq + Position_Y ^ 2
          SumXsq = SumXsq + Position_X ^ 2
          Index = Index + 1

        End If
      Next LineN
     Next A
 End If

   If ((SumX = 0) Or (SumY = 0) Or (SumX * SumY = 0)) Then
      GetSlope = 0
```

```
   Else
      If (Choice = 1 Or Choice = 2) Then
         GetSlope = ((SumXY) - ((SumX * SumY) / Index)) / ((SumYsq) - ((SumY * SumY) / Index))
      End If

      If (Choice = 3) Then
         FuncDumy = ((SumXY) - ((SumX * SumY) / Index)) / ((SumYsq) - ((SumY * SumY) / Index))
         GetSlope = (SumX - (FuncDumy * SumY)) / Index
      End If

      If (Choice = 0) Then
         FuncDumy = Sqr((SumXsq - (SumX ^ 2 / Index)) * (SumYsq - (SumY ^ 2 / Index)))
         GetSlope = ((SumXY) - ((SumX * SumY) / Index)) / FuncDumy

      End If
   End If

End Function
Function dblSquare(SquareMe As Integer) As Double

    dblSquare = SquareMe ^ 2 '* SquareMe

End Function
Function Measure_Distance(c1 As Double, m1 As Double, Point2_X As Integer, Point2_Y As Integer)
As Double

Dim Point1_X, Point1_Y As Long
Dim c2 As Long

c2 = Point2_X - ((-1 / m1) * Point2_Y)
Point1_X = (c2 * m1 - c1 * (-1 / m1)) / (m1 - (-1 / m1))
Point1_Y = (c2 - c1) / (m1 - (-1 / m1))
Measure_Distance = Sqr((Point2_X - Point1_X) ^ 2 + (Point2_Y - Point1_Y) ^ 2)

End Function

Private Sub Frame4_DragDrop(Source As Control, X As Single, Y As Single)

End Sub
```

Form5 - 1

```
Private Sub Back_Click()

Unload Form5
Form4.Show

End Sub

Private Sub Picture2_Click()

End Sub

Private Sub Quit_Click()

Unload Form5
Exit Sub

End Sub
Private Sub ShowRes_Click()

Dim NewLine As String

On Error GoTo FileError
Open "c:\windows\desktop\InspResults.txt" For Input As #1
Do Until EOF(1)
   Line Input #1, NewLine
   TEXT1.Text = TEXT1.Text + NewLine + vbCrLf
Loop

Exit Sub

FileError:
  MsgBox "File Error! "

End Sub
```

```
Form1 - 1

Private Sub Timer1_Timer()

Dim PauseTime, Start

    PauseTime = 2    ' Set duration.
    Start = Timer    ' Set start time.
    Do While Timer < Start + PauseTime
        DoEvents     ' Yield to other processes.
    Loop
        Unload Me
    Form2.Show

End Sub
```

```
VERSION 5.00
Begin VB.Form Form1
   Caption         =   "HMD TESTER"
   ClientHeight    =   4140
   ClientLeft      =   60
   ClientTop       =   345
   ClientWidth     =   7890
   LinkTopic       =   "Form1"
   ScaleHeight     =   4140
   ScaleWidth      =   7890
   StartUpPosition =   3  'Windows Default
   Begin VB.Frame Frame1
      Height          =   4050
      Left            =   0
      TabIndex        =   0
      Top             =   0
      Width           =   7905
      Begin VB.Timer Timer1
         Interval        =   1000
         Left            =   6960
         Top             =   3360
      End
      Begin VB.Label lblCompanyProduct
         AutoSize        =   -1  'True
         Caption         =   "US AARL"
         BeginProperty Font
            Name            =   "Arial"
            Size            =   18
            Charset         =   0
            Weight          =   700
            Underline       =   0   'False
            Italic          =   0   'False
            Strikethrough   =   0   'False
         EndProperty
         Height          =   435
         Left            =   3240
         TabIndex        =   8
         Top             =   600
         Width           =   1590
      End
      Begin VB.Label lblLicenseTo
         Alignment       =   1  'Right Justify
         Caption         =   "******"
         BeginProperty Font
            Name            =   "Arial"
            Size            =   8.25
            Charset         =   0
            Weight          =   400
            Underline       =   0   'False
            Italic          =   0   'False
            Strikethrough   =   0   'False
         EndProperty
         Height          =   255
         Left            =   3960
         TabIndex        =   7
         Top             =   360
         Width           =   3495
      End
      Begin VB.Label lblProductName
         AutoSize        =   -1  'True
         BackColor       =   &H80000018&
         Caption         =   "HMD TESTER"
         BeginProperty Font
            Name            =   "Arial"
            Size            =   32.25
            Charset         =   0
            Weight          =   700
            Underline       =   0   'False
            Italic          =   0   'False
```

```
         Strikethrough    =   0    'False
      EndProperty
      Height          =   765
      Left            =   3240
      TabIndex        =   6
      Top             =   1140
      Width           =   4245
   End
   Begin VB.Label lblPlatform
      Alignment       =   1  'Right Justify
      AutoSize        =   -1  'True
      Caption         =   "Platform: PC"
      BeginProperty Font
         Name            =   "Arial"
         Size            =   15.75
         Charset         =   0
         Weight          =   700
         Underline       =   0   'False
         Italic          =   0   'False
         Strikethrough   =   0   'False
      EndProperty
      Height          =   360
      Left            =   4950
      TabIndex        =   5
      Top             =   2340
      Width           =   1905
   End
   Begin VB.Label lblVersion
      Alignment       =   1  'Right Justify
      AutoSize        =   -1  'True
      Caption         =   "Version: 1.0"
      BeginProperty Font
         Name            =   "Arial"
         Size            =   12
         Charset         =   0
         Weight          =   700
         Underline       =   0   'False
         Italic          =   0   'False
         Strikethrough   =   0   'False
      EndProperty
      Height          =   285
      Left            =   5490
      TabIndex        =   4
      Top             =   2700
      Width           =   1365
   End
   Begin VB.Label lblWarning
      Caption         =   "Supported by US AARL and Army Summer Faculty Research Program"
      BeginProperty Font
         Name            =   "Arial"
         Size            =   8.25
         Charset         =   0
         Weight          =   400
         Underline       =   0   'False
         Italic          =   0   'False
         Strikethrough   =   0   'False
      EndProperty
      Height          =   195
      Left            =   150
      TabIndex        =   3
      Top             =   3660
      Width           =   6855
   End
   Begin VB.Label lblCompany
      Caption         =   "August, 1999"
      BeginProperty Font
         Name            =   "Arial"
         Size            =   8.25
         Charset         =   0
```

```
            Weight          =   400
            Underline       =   0    'False
            Italic          =   0    'False
            Strikethrough   =   0    'False
         EndProperty
         Height          =   255
         Left            =   4560
         TabIndex        =   2
         Top             =   3270
         Width           =   2415
      End
      Begin VB.Label lblCopyright
         Caption         =   "Sheng-Jen (""Tony"") Hsieh, Ph.D."
         BeginProperty Font
            Name            =   "Arial"
            Size            =   8.25
            Charset         =   0
            Weight          =   400
            Underline       =   0    'False
            Italic          =   0    'False
            Strikethrough   =   0    'False
         EndProperty
         Height          =   255
         Left            =   4560
         TabIndex        =   1
         Top             =   3060
         Width           =   2415
      End
      Begin VB.Image imgLogo
         Height          =   3105
         Left            =   240
         Picture         =   (Bitmap)
         Stretch         =   -1  'True
         Top             =   360
         Width           =   2655
      End
   End
End
```

Form2 - 1

```
Private Sub cmdQUIT_Click()

Unload Form2
End

End Sub

Private Sub Command2_Click() 'Image Analysis

    Unload Form2
    Form4.Show

End Sub


Private Sub Command1_Click() 'Image Capture

    Unload Form2
    Form3.Show

End Sub

Private Sub Results_Click()

    Unload Form2
    Form5.Show

End Sub
```

```
VERSION 5.00
Begin VB.Form Form2
   Caption         =   "Main Menu"
   ClientHeight    =   4185
   ClientLeft      =   60
   ClientTop       =   345
   ClientWidth     =   6165
   LinkTopic       =   "Form2"
   ScaleHeight     =   4185
   ScaleWidth      =   6165
   StartUpPosition =   3  'Windows Default
   Begin VB.CommandButton cmdQUIT
      Caption         =   "Quit"
      BeginProperty Font
         Name            =   "Comic Sans MS"
         Size            =   8.25
         Charset         =   0
         Weight          =   400
         Underline       =   0   'False
         Italic          =   0   'False
         Strikethrough   =   0   'False
      EndProperty
      Height          =   375
      Left            =   5520
      TabIndex        =   4
      Top             =   3720
      Width           =   495
   End
   Begin VB.CommandButton Image_Capture
      Caption         =   "Image Capture"
      BeginProperty Font
         Name            =   "Comic Sans MS"
         Size            =   8.25
         Charset         =   0
         Weight          =   400
         Underline       =   0   'False
         Italic          =   0   'False
         Strikethrough   =   0   'False
      EndProperty
      Height          =   375
      Left            =   0
      TabIndex        =   3
      Top             =   3720
      Width           =   1335
   End
   Begin VB.CommandButton Command2
      Caption         =   "Image Analysis"
      BeginProperty Font
         Name            =   "Comic Sans MS"
         Size            =   8.25
         Charset         =   0
         Weight          =   400
         Underline       =   0   'False
         Italic          =   0   'False
         Strikethrough   =   0   'False
      EndProperty
      Height          =   375
      Left            =   1440
      TabIndex        =   2
      Top             =   3720
      Width           =   1335
   End
   Begin VB.CommandButton Results
      Caption         =   "Results"
      BeginProperty Font
         Name            =   "Comic Sans MS"
         Size            =   8.25
         Charset         =   0
         Weight          =   400
```

```
         Underline       =   0    'False
         Italic          =   0    'False
         Strikethrough   =   0    'False
      EndProperty
      Height          =   375
      Left            =   2880
      TabIndex        =   1
      Top             =   3720
      Width           =   1215
   End
   Begin VB.CommandButton Command4
      Caption         =   "Help"
      BeginProperty Font
         Name            =   "Comic Sans MS"
         Size            =   8.25
         Charset         =   0
         Weight          =   400
         Underline       =   0    'False
         Italic          =   0    'False
         Strikethrough   =   0    'False
      EndProperty
      Height          =   375
      Left            =   4200
      TabIndex        =   0
      Top             =   3720
      Width           =   1215
   End
   Begin VB.Image Image1
      Height          =   4140
      Left            =   0
      Picture         =   (Bitmap)
      Stretch         =   -1  'True
      Top             =   0
      Width           =   6240
   End
End
```

Form3 - 1

```
Private Sub Continue_Click()

Unload Form3
Form4.Show

End Sub

Private Sub Quit_Click()

Unload Form3
Form2.Show

End Sub
```

```
VERSION 5.00
Begin VB.Form Form3
   AutoRedraw      =   -1  'True
   Caption         =   "Image Capture"
   ClientHeight    =   3690
   ClientLeft      =   60
   ClientTop       =   345
   ClientWidth     =   7605
   BeginProperty Font
      Name            =   "Comic Sans MS"
      Size            =   8.25
      Charset         =   0
      Weight          =   400
      Underline       =   0   'False
      Italic          =   0   'False
      Strikethrough   =   0   'False
   EndProperty
   LinkTopic       =   "Form3"
   Picture         =   (Bitmap)
   ScaleHeight     =   3690
   ScaleWidth      =   7605
   StartUpPosition =   3  'Windows Default
   Begin VB.CommandButton Continue
      Caption         =   "Continue"
      Height          =   375
      Left            =   3600
      TabIndex        =   8
      Top             =   3240
      Width           =   855
   End
   Begin VB.TextBox Help
      Alignment       =   2  'Center
      BorderStyle     =   0  'None
      DragMode        =   1  'Automatic
      Height          =   285
      Left            =   6960
      TabIndex        =   6
      Text            =   "Help"
      Top             =   2880
      Width           =   495
   End
   Begin VB.TextBox Text2
      Alignment       =   2  'Center
      BorderStyle     =   0  'None
      Height          =   285
      Left            =   5880
      TabIndex        =   5
      Text            =   "User Manual"
      Top             =   2880
      Width           =   975
   End
   Begin VB.TextBox Capure
      Alignment       =   2  'Center
      BorderStyle     =   0  'None
      Height          =   285
      Left            =   4560
      TabIndex        =   4
      Text            =   "View & Capture"
      Top             =   2880
      Width           =   1215
   End
   Begin VB.CommandButton Quit
      Caption         =   "Quit"
      Height          =   375
      Left            =   2400
      TabIndex        =   0
      Top             =   3240
      Width           =   735
   End
```

```
   Begin VB.Label Label1
      BackColor       =   &H00FFFFFF&
      Caption         =   "Double click to activate"
      Height          =   255
      Left            =   5400
      TabIndex        =   7
      Top             =   2520
      Width           =   1815
   End
   Begin VB.OLE OLE3
      BackColor       =   &H00C0C0C0&
      Class           =   "Package"
      DisplayType     =   1  'Icon
      Height          =   375
      Left            =   6960
      SourceDoc       =   "C:\Program Files\MRT micro\MRT VideoPort Professional\User Manuals\Ed
      TabIndex        =   3
      Top             =   3240
      Width           =   615
   End
   Begin VB.OLE OLE2
      BackColor       =   &H00C0C0C0&
      DisplayType     =   1  'Icon
      Height          =   375
      Left            =   5880
      SourceDoc       =   "C:\WINDOWS\twain\Camdrv80\Camdrive.hlp"
      TabIndex        =   2
      Top             =   3240
      Width           =   975
   End
   Begin VB.OLE OLE1
      BackColor       =   &H00C0C0C0&
      DisplayType     =   1  'Icon
      Height          =   375
      Left            =   4560
      SourceDoc       =   "C:\Program Files\MRT micro\MRT VideoPort Professional\Image Wizard\Ri
      TabIndex        =   1
      Top             =   3240
      Width           =   1215
   End
   Begin VB.Image Image1
      Height          =   3705
      Left            =   240
      Picture         =   (Bitmap)
      Top             =   0
      Width           =   8070
   End
End
```